IODP Expedition 339: Mediterranean Outflow

Site U1385 Summary

Background and objectives

Site U1385 (proposed site SHACK-04A) is located on the southwestern Iberian Margin (37°34.285' N and 10°7.562' W), near the position of core MD01-2444, which has been studied extensively to understand millennial-scale climate variability during the last and penultimate glaciation. The overall objective of this site is to recover a late Pleistocene sediment record that will greatly improve the precision with which marine sediment records of climate change can be correlated to and compared with polar ice cores and European terrestrial records.

Site U1385 was occupied on 25 November 2011. Five holes were cored at this site using the advanced piston corer (APC) system and non-magnetic core barrels to obtain a complete sedimentary record. Four holes were cored to ~150 m and one (U1385C) to just 9.5 m (one core). A total of 67 cores were required to obtain 622 m of sediment (103% recovery). The third-generation advanced piston corer temperature tool (APCT-3) was deployed 12 times.

Main results

The sediments at Site U1385 are defined as a single lithologic unit (Unit I). Unit I is a very uniform lithology composed of a Holocene-Pleistocene sequence dominated by bioturbated calcareous muds and calcareous clays, which vary in the relative proportion of biogenic carbonate material (23-39%) evident as color variation from lighter (i.e., more calcareous) to darker (i.e., more terrigenous) sediment. Relatively more terrigenous-dominated sediments are present in the upper quarter of Unit 1, but their occurrence does not warrant the definition of any additional lithologic units or subunits. No primary sedimentary structures were observed. However, bioturbation is the most obvious secondary sedimentary structure, which ranges from sparse to moderate. Other features, such as small-scale subvertical microfaults and contorted beds, are present at several depth intervals. These features are local and of minor importance and do not seriously disrupt the continuity of the stratigraphic section. The entire section cored at this site is therefore considered as typical hemipelagic deposits, with average sedimentation rates of ~10 cm/ky.

The five holes cored at Site U1385 provided ample sediment for constructing a complete spliced stratigraphic section, containing no notable gaps or disturbed intervals. A primary splice was constructed using all holes, which provides a complete composite section for all physical and magnetic properties measured using pass-through, multisensor tracks. Two nearly complete

secondary splices were also constructed, with one using intervals from Holes U1385A and -B and the other using intervals from Holes U1385D and E. These alternate splices will maximize the core material available for sampling.

The biostratigraphy of Site U1385 is based on the shipboard study of calcareous nannofossils, planktonic and benthic foraminifers in core catcher samples from Holes U1385A, B, C, and D, and the five lowermost of Hole U1385E. Nannofossils and planktonic foraminifers were very abundant and relatively well preserved in all samples. Benthic foraminifers were also relatively abundant and diverse; however, ostracods were rare and pteropods were not observed in any samples downhole with the exception of the mudline sample. Pollen and spore content was generally abundant and moderately well preserved, providing an excellent opportunity for marine-terrestrial correlations. The chronological framework for Site U1385 was mainly based on calcareous nannofossil and planktonic foraminifer events as well as one benthic foraminifer datum, suggesting a continuous Pleistocene record with a nearly uniform sedimentation rate of about 10 cm/ky. The age of the base of the section is estimated to be ~1.4 Ma.

The intensity of natural remanent magnetization (NRM) ranges from $\sim10^{-5}$ to $\sim10^{-3}$ A/m. Within the upper 50 mbsf, the intensity is on the order of 10^{-2} A/m, but below ~50 mbsf the intensity decreases to $\sim10^{-3}$ to $\sim10^{-5}$. The correlation between the remanent intensity and magnetic susceptibility suggests that the magnetic minerals that carry the NRM are the same grains that dominate the magnetic susceptibility. Magnetic susceptibility varies between 10 and 50×10^{-5} (SI volume units). The Brunhes/Matuyama polarity transition (0.781 Ma) as well as the termination and beginning of the Jaramillo Subchron (C1r.1n) (0.988 and 1.072 Ma respectively) are identified at Site U1385. In addition, a brief normal polarity interval is tentatively interpreted to represent the Cobb Mountain Subchron (C1r.2n, 1.173-1.185 Ma). Postcruise paleomagnetic analysis of Site U1385 should provide a reliable record of variations in relative paleointensity of Earth's geomagnetic field.

The most remarkable aspect of all physical property records at Site U1385 is a gradual reduction of magnetic susceptibility (MS) values beginning about 30 mbsf. In the upper few meters, susceptibility values range from 20-40 SI, increase to a maximum of 40-60 SI with peaks of up to 90 SI at ~20 mbsf, and decline afterwards to an absolute low of 10 SI between 50-60 mbsf. Afterwards they recover, but remain relatively steady at a low level between 10-20 SI. Despite the reduction in intensity, magnetic susceptibility displays distinct high-amplitude variability until 50 mbsf, being comparatively low and less variable downhole. This main change between 30 and 50 mbsf seems to correspond to a general change in lithology and/or diagenetic overprint, e.g. mirrored in low NGR counts and high L* values. A likely cause for the overall

decrease of magnetic susceptibility is the reduction of fine-grained magnetite to iron sulfides within the sulfate reduction zone. High-frequency variations show a close correlation to GRA densities, likely reflecting varying relative amounts of clay and carbonate. There is also a notable positive correlation between NGR and MS below 40 m, which is not apparent above this depth, hinting at a change in the factors influencing the sedimentary composition during this interval.

Organic carbon is generally low (<1 wt%) and the C/N ratio, indicates that the organic C is mainly of marine origin. Diagenesis of organic matter has led to the depletion of dissolved sulfate in interstitial waters. In this process, sulfate is consumed and alkalinity, ammonium, and phosphate are byproducts. The increase in alkalinity promotes authigenic precipitation of carbonate minerals (e.g., calcite and dolomite), consistent with a decrease in magnesium and calcium concentrations in the sulfate reduction zone. Hydrogen sulfide ion produced by sulfate reduction and anaeorobic methane oxidation can react with iron to form iron sulfide minerals, which are paramagnetic and have lower susceptibility than magnetite. This process may explain the decrease in magnetic susceptibility observed below ~40 m. Oxygen and hydrogen isotope values of interstitial water show considerable variability in the upper 30 mbsf that is unexpected from a profile that should be dominated by diffusion.

The measured geothermal gradient at Site U1385 is about 39.2°C/km and the estimated heat flow is 47.5 mW/m^2, which is in the lower half of the normal range for heat flow on the Portuguese margin.

Highlights

Exactly as predicted, coring at Site U1385 recovered a continuous 1.4-my record (lithologic Unit I) of hemipelagic deposits with an average sedimentation rate of ~10 cm/ky. The multiple spliced records recovered from the five holes provide essential material needed for postcruise studies of millennial-scale climate variability through the Middle Pleistocene Transition (MPT). The record will serve as a marine reference section of Pleistocene climate variability, and will significantly improve the precision with which marine climate records can be correlated to polar ice cores and terrestrial sequences.